THE CARE OF HOME AQUARIA

OSBURN

NEW YORK
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The salt-water jars are near the windows, the fresh-water ones beneath skylights. These aquaria have been much used for observation by public school teachers and their classes.

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THE CARE OF HOME AQUARIA

OSBURN

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PREFACE.

This volume of the New York Aquarium Nature Series has been prepared with a view to giving concise information as to the best methods of caring for small aquaria in the home. It deals especially with the balanced aquarium, since this is undoubtedly the best type of aquarium for home use. Not only does it approach more nearly to the natural conditions of life in small ponds, and therefore is of more value as an object for study, but it is easier to care for and is independent of all connections with water pipes and machinery. It is, of course, quite possible to have a circulation of water even in small aquarium tanks, but this involves connections with water pipes or complicated machinery with greater expense. The balanced aquarium requires no costly or complicated apparatus;—merely a tank with a few of the simplest implements, which, for the most part, can just as well be made at home. Such aquaria yield a maximum of interest with a minimum of care and expense and are, therefore, the most useful of all small aquaria.

Requests for information as to the care of such aquaria have been received so frequently at the New York Aquarium, that in March, 1912, the writer prepared for publication a bulletin entitled "The Balanced Aquarium" (Bulletin No. 50, New York Zoological Society, March, 1912). An edition of 1000 copies was placed on sale at the Aquarium, but this was exhausted in a few months. The demands for information have not ceased, however, and to meet this need the former bulletin has been rewritten and much extended and is again offered to the public under the present title.

No attempt has been made to discuss the various animals and plants of the Aquarium, since this would necessitate a very much larger volume. It is the writer's intention merely to explain the conditions of life in the balanced aquarium and to indicate how those conditions can best be maintained in the simplest fashion.

The work is not intended for those who are already experienced aquarists, but for the use of beginners in the subject who wish to become expert in this delectable occupation.

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THE CARE OF SMALL AQUARIA

By RAYMOND C. OSBURN, Ph. D.

ASSISTANT DIRECTOR OF THE NEW YORK AQUARIUM.

INTRODUCTION.

Small aquaria as objects of interest and decoration in the house have become so common that their presence no longer attracts special comment, though the custom of keeping them is of comparatively recent origin. Goldfishes have been bred by the Chinese and other oriental peoples for several centuries, but chiefly in small out-door pools in the gardens.

The balanced aquarium has been clearly defined by Mr. Henry D. Butler, in a book entitled, "The Family Aquarium" (New York, 1858), in the following terms: "The aquarium is a receptacle for aquatic animal and vegetable life in fresh or salt water, which need never be changed. The old-fashioned fish globes were not aquaria in the proper sense, because it was absolutely necessary to change the water in them pretty frequently, lest the fish die. The vitalization of the water without this change comprehends the leading principle of the aquarium." Undoubtedly the failure to grasp the principle of proper balance was the special factor which prevented the small aquarium from becoming popular at a much earlier period.

The facts that animals require oxygen in respiration and that green plants give off oxygen in excess were discovered and published as early as 1778, but lovers of aquatic life were slow to apply this knowledge. In fact, it was not until 1850 that the first properly balanced aquarium was described by Mr. Robert Warrington of Manchester, England, in a paper entitled, "On the Adjustments of the Relations Between the Animal and Vegetable Kingdoms, by Which the Vital Functions of both are Permanently Maintained."

Warrington found that goldfishes could be maintained indefinitely in a glass jar in which was placed some tapegrass (*Vallisneria*) to supply the oxygen and with the addition of a few pond snails to clean up decayed vegetation. Further experiments were then conducted by him along similar lines upon ma-

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rine animals and plants, and published in the Annals of Natural History for November, 1853.

The work of Mr. Philip Henry Gosse was also of the greatest importance in developing the balanced aquarium, and his book, "The Aquarium, an Unveiling of the Wonders of the Deep Sea," published in 1854, showed how rapid had been the advancement in the study of the marine aquarium.

In England and Germany the small balanced aquarium soon became popular in the home. In America comparatively little attention has been paid to it, although a few enthusiastic lovers of aquatic life have maintained aquaria with great success from the time the principle first became known. The late Mr. William Emerson Damon in his book, "Ocean Wonders," credited Miss Elizabeth E. Damon, of Windsor, Vermont, with the honor of being the first person in the United States to keep a properly balanced aquarium, the receptacle being a two-quart jar supplied with fishes, tadpoles and pondweed (*Potamogeton*).

The idea is still prevalent, born of the old days of fish globes and persisting through ignorance, like many other exploded notions, that the aquarium requires a vast amount of time and fussing and especially that the more frequently the water is changed, the better it will be for the animal life. Nothing could be farther from the truth, for when a balance is secured the less changing of anything the better it will be, for fear of disturbing the nice adjustment which Nature has set up and *the water should not be changed at all.* Yet anyone maintaining a balanced aquarium will agree that the question first and most frequently asked by the interested visitor is, "How often do you have to change the water?" The writer has known persons who for years had kept aquaria equipped with plants and animals for proper balance, who still thought it necessary to change daily all or part of the water in order to maintain the animal life.

The writer well recalls his own early attempts as a child to keep small native fishes in an aquarium made of a cast-off wash-boiler partially sunk in the ground in the garden, and the ingenuity with which he rigged a small tube to the pump-spout by the horse trough so that when anyone pumped water a small portion would escape for the benefit of the fishes. A few water weeds would have done the work of aeration more successfully and with much less trouble; the knowledge of the proper method was lacking, and after a number of abortive attempts the experiment was given up in despair. I have no doubt that thousands

YELLOW PERCH.

of persons have had similar experiences with various kinds of fish globes and other improper aquarium apparatus.

Another prevailing notion is, that the small aquarium is simply a plaything serving to amuse the children or to afford an outlet for the energies of an occasional crank and that its only other excuse for existence is found in the fact that the green plants and goldfishes make a bright spot in the room. Even if this were all, who will deny that its existence is justified? But excuses are not necessary. Let it serve for the one as a plaything or a bright spot in the room, but for the person who cares to study the life in the aquarium—and there is a constantly increasing number—the aquarium becomes a piece of scientific apparatus from which can be learned many of Nature's laws that regulate the outside world.

The unbalanced fish globe with its occasional renewal of water is unnatural—as unnatural as the attempt of a person to live in a closet by opening the door once a day, filling the space with fresh air, then shutting off all ventilation until the next day. The cases, as far as respiration is concerned, are exactly parallel.

It is possible to supply oxygen to fishes in the small aquarium by pumping air into the water and a great many kinds of apparatus have been devised for this purpose. Some of these

Salt Water.

Fresh Water.

BALANCED AQUARIA.

run by water power, some by small electric motors, some by weights or clockwork, etc., and of course all of them have been patented. They have this advantage, that a larger number of fishes may be maintained in a given quantity of water than is possible in the balanced aquarium. But in the opinion of the writer this display of inventive genius has been largely misdirected, for the properly balanced home aquarium will support a sufficient amount of animal life for all ordinary purposes without artificial aeration. Besides the balanced aquarium is much more instructive since it approaches more nearly to natural conditions.

The balance of plant and animal life means complete and continual ventilation. Not only is oxygen supplied in sufficient quantities by the plants, but the carbon dioxide given off by the animals in respiration is consumed by the plants in the process of starch making. The adjustment is Nature's own and all animals are adapted to it. Such an arrangement is a pond in miniature and may be used in the scientific study of aquatic life of various kinds. In the majority of cases, to be sure, only goldfishes are kept, in addition to a few tadpoles or snails and plants. According to the interests of the aquarist, however, this may be varied indefinitely. Many other attractive exotic fishes of striking colors, form and habits may be readily secured from dealers, or the collector may take up the study of local native fishes, the natural history of which will be found no less interesting than that of the exotic species.

Aquatic insects afford a most interesting and almost infinitely varied field for study, and their habits, metamorphoses, etc., may be most readily investigated by this means. Again, if the aquarist is interested in aquatic botany, he will find here excellent opportunities and means for studying many water plants. Marine life is even more varied than that of the freshwater, and endless opportunities are afforded to those who live within reach of the sea. The microscopist will also find a constantly changing and ever interesting field of research in the minute life of the aquarium.

As an adjunct to the scientific laboratory, the aquarium has become a necessity. Here it may vary in size from the common finger-bowl for minute animals to tanks for the larger forms. The various aquatic laboratories such as those at Wood's Hole, Massachusetts, and at Naples in Italy, to cite two of the best known, make constant use of aquaria and could scarcely exist

without them. Nearly all colleges and universities have some means of maintaining aquaria, usually of the balanced sort, while a few even possess facilities for the storage and circulation of sea water in larger tanks.

Naturally, larger aquaria have the advantage of supporting a larger and more varied stock, but it should be borne in mind that for scientific as well as for other purposes, the proper adjustment is of far greater value than mere space or variety of life. In the high-school, grade-school and even in the kindergarten, balanced aquaria have found a place where they encourage nature study among the children. The New York Aquarium has equipped hundreds of these for various schools in New York City.

THE MEANING OF BALANCE.

The factors which govern life in the balanced aquarium are the same as those which obtain elsewhere in nature, with the important difference that certain of them are under control. In fact we may consider the aquarium as a miniature pond in which the conditions of food, temperature and aeration are under the control of the operator. In the natural pond the variations of temperature alone are sufficient to produce important cycles in the balance and in the life of the organisms.

To secure and maintain a balance in the indoor aquarium is the most important problem which confronts the amateur aquarist. Temperature, which is such an important factor in the natural pond, can easily be controlled indoors within the limits of variation which are likely to affect seriously the inhabitants of the aquarium. Similarly the light factor usually offers but little difficulty, and food can easily be added in the necessary quantities.

The problem of aeration is more difficult. In the natural pond, with its large surface ruffled by the breeze, this takes care of itself, since a sufficient amount of oxygen can be absorbed from the air to supply all the animals that can find food within its waters; but in the narrow limits of the aquarium, with its restricted surface, comparatively greater depth and the absence of any agitation of the water, the absorption of oxygen at the surface does not take place with sufficient rapidity to sustain much animal life.

To supplement the surface absorption of oxygen, it is necessary to grow plants in the aquarium. It is a well known fact

A BALANCED SALT WATER AQUARIUM.

that in manufacturing their own food from simple substances plants give off oxygen as a waste product. This process is accomplished by the green matter of the plant, a special kind of protoplasm known as chlorophyll. In the submerged plants of the aquarium the oxygen passes off directly by absorption into the water. The fishes are thus supplied with oxygen given off by the plants as waste substance.

Having absorbed the oxygen into the blood by means of the gills, the fishes combine it with the carbon of the food to obtain energy, and, in the process of respiration, give off to the water quantities of carbon dioxide, or carbonic acid gas, as a waste

substance. This gas, composed of carbon and oxygen, is absorbed by the plants and the carbon used in the process of starch making, while the oxygen is returned to the water again as a waste substance. Thus the animals and the plants of the aquarium are mutually benefited, each supplying something that is required in the life processes of the other.

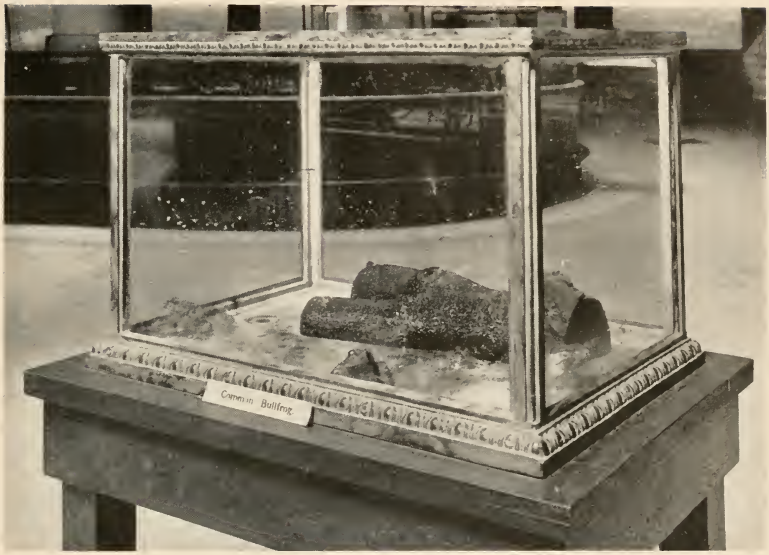
Plants, however, are able to manufacture starch, and consequently absorb carbon dioxide and release oxygen, only when they are exposed to sunlight. It follows then that on dark days the plants have less capacity for aeration than on bright days, and that they yield more oxygen in sunny windows than in dark corners. Moreover they can make starch and consume carbon dioxide and yield oxygen only during the daytime. Further than this, they consume a small amount of oxygen in their own respiration both day and night, so that at times when they are not engaged in starch-making they tend to consume a part of the oxygen of the aquarium, although in a night they can use only a small portion of that thrown off during the day. If the water of the standing aquarium is supplied with an excess of oxygen during the day, a considerable amount of the oxygen will remain in solution in the water and aid in proper aeration throughout the night.

It is evident then that an aquarium well stocked with plants will support a larger quantity of animal life during the day and in bright weather than it will at night or on dark days. The animal life of the standing aquarium must therefore be regulated to meet the poorest rather than the best conditions of oxygen production by the plant life.

Temperature also affects the rate of starch-making and consequently of oxygen elimination, as the protoplasm of the plant is more active in a higher than a lower temperature. However, the fishes are also less active in colder water and consume less oxygen, so that these factors balance each other and temperature does not especially affect the aeration of the well-balanced aquarium.

THE AQUARIUM TANK.

Undoubtedly the best kind of a receptacle for the beginner is the oblong, straight-sided aquarium with metal frame, glass sides and slate or soap-stone bottom. The medium sizes holding from eight to ten gallons, up to twenty gallons, will be the best for the beginner. The smaller sizes are more difficult to balance



PORTABLE METAL FRAME AQUARIUM.
A useful tank in all sizes and the only kind that is satisfactory for larger sizes above eight or ten gallons.

and the larger ones are more expensive. For aquaria holding ten gallons and upward, the only type that can be used to advantage is that with metal frame.

When well set up such a tank will last for years without leaking, and is easily reset, or can often be readily mended by running a little asphaltum, red lead or an aquarium cement in the joints.

The rectangular, straight-sided, all-glass jars, holding up to eight or ten gallons, are excellent; better in some respects than those with metal frames, for they are not likely to spring a leak. The glass jars, however, are more likely to crack and so prove an extra expense, but in the hands of the experienced aquarist they are perhaps the most satisfactory kind for sizes under five gallons. Care should be taken to see that such jars rest firmly and evenly upon their bases, and that they are not subject to sudden changes of temperature. It is well to place an asbestos mat, or a pad composed of a few layers of blotting paper, under the jar to act as a shock absorber and to distribute the weight more evenly.

The cylindrical jar with straight vertical sides is satisfactory to maintain, but the inmates appear somewhat distorted

MOSQUITO LARVAE: ALL-GLASS AQUARIUM.
This rectangular type of jar can be had in all the smaller sizes and is the best form of the all-glass jar. For balanced aquaria, the height should not exceed the width.

through the curved sides. For smaller aquaria the ordinary battery jar is as good as anything, except for the distortion, and has the advantage of being cheap. Very beautiful and well balanced aquaria can often be made with the two-quart size, but these are suitable only for very small animals and few of them.

To test the limits of the capacity of the two-quart size, the writer once kept in such a jar, with plenty of weeds and in good light, a carp nearly as long as the diameter of the vessel. The fish continued to live in good condition for several weeks until an accident brought the experiment to an abrupt end.

On no account should the ordinary globe be used. This is the unanimous opinion of all experienced aquarists. Globes are

often purchased by the inexperienced because of their cheapness, but they give the specimens a very badly distorted appearance, and, what is much worse, the constricted top affords but small surface area for exchange of gases with the air. Furthermore the constriction of the top makes it almost impossible to clean the jar properly without emptying it, and this naturally disturbs the balance. The fact that a goldfish will live in a small globe, with or without a small floating branch of a water plant, is no excuse for keeping it in any but the most comfortable surroundings. Fishes in such globes—and how often we see them!—are compelled to go often to the surface and suck in bubbles of air to obtain enough oxygen to avoid asphyxiation. The slight additional cost in securing the proper sort of a tank will be repaid many times in the satisfaction with which it may be managed.

To prevent the fish from jumping out of the tank a cover of wire screen may be provided. As a rule there is little danger of this unless the tank is filled close to the top, but some kinds of active fishes are much given to leaping out of the water.

TEMPERATURE.

For native animals in general the degree of temperature is of comparatively small importance, provided that the water is not allowed to get too warm, as it will tend to do in summer if the direct rays of the sun are permitted to reach it for any length of time. Native fishes, as well as goldfishes and carp, will endure the colder temperatures so long as the water is not allowed to freeze, though the nearer the freezing point it approaches, the more sluggish become their movements and the less food they will consume. The most satisfactory temperature is perhaps between the degrees of 50 and 70 Fahrenheit. It should be prevented from rising higher than 80 degrees or from falling below 40, though there is much less danger from the lower temperatures than from the higher. Some exotic fishes from the tropics require a warm temperature and die when the water falls below 60. Young turtles and alligators become torpid and refuse to eat if the temperature goes down much below 70 and should always be kept at a hot-house temperature to make the best growth.

It is very important for all animals that the temperature should not vary suddenly, since in their natural environment they are not subjected to such rapid changes and hence are not adapted to them. Fishes, especially the long-tailed varieties of

GOURAMI
This exotic specimen lived for several years at the Aquarium.

goldfishes, may have the tissues of the fins injured by exposure to sudden changes in temperature, rendering them liable to the disease known as "tail-rot." Aquaria should, therefore, be kept out of cold draughts in the winter time and water should be added only when it is at the same temperature as that of the aquarium.

For tropical fishes which require higher water temperatures the year round, 75 to 80 degrees or more, various devices have been invented. Several of these are quite satisfactory, even with small tanks. When specially constructed tanks or other apparatus are required, it will be best to consult a dealer in aquarium supplies in regard to the matter.

It is possible to heat a tank by means of electric light bulbs placed near the tank, and a little careful experimentation with the aid of the thermometer will indicate how close the bulb should be placed. But the best appliances involve means of circulating the water so as to maintain nearly the same temperature in all parts of the aquarium.

PLACING THE AQUARIUM.

The aquarium jar or tank should be placed on a firm base where it will not be subjected to much vibration and where it

YOUNG LONG-EARED SUNFISH IN A BALANCED AQUARIUM.
Smaller specimens of native sunfishes make as attractive aquarium pets as could be desired and are easily kept. Note variety given by two kinds of plants.

will not have to be moved frequently. Fishes are sensitive to vibrations in the water and jarring or moving the aquarium frightens and disturbs the inhabitants. It should not be placed too near a radiator, and if it is near a window it should be carefully guarded from draughts in cold weather. North windows are the most suitable, since sufficient light is afforded for the growth of the plants, and the direct rays of the sun, which tend to heat up the water and to over-stimulate the plant growth, will be avoided. If the southern exposure is the only one available, the tank may be placed farther from the window or it may be shaded from the strong sunlight by a small screen of cheesecloth stretched upon a light frame.

Too much light is not good for the plants, yet they must have enough for starch-making or they will not thrive. At the New York Aquarium small aquaria have been kept for years in a satisfactory condition of balance, though situated under skylights where the direct rays of the sun never strike them.

PLANTING THE AQUARIUM.

This is an important proceeding, as upon the successful establishment of the plant growth depends the aeration of the standing aquarium and consequently the health of the animals.

SPECIMENS OF THE AXOLOTL, NEW YORK AQUARIUM.

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Many kinds of aquatic plants, both wild and cultivated, will grow readily in the narrow limits of the aquarium.

Fine gravel or coarse sand, or a mixture of these should first be placed in the bottom of the tank to the depth of one or two inches, depending upon the depth of the aquarium. For the best results the sand should not be evenly distributed over the bottom, but should slope toward the center, side or end of the small tank, or have two or three depressions if the tank is larger. These not only add diversity to the appearance, but the fecal matter of the fishes, surplus food and other wastes will collect in the depressions and can be more readily siphoned off.

The plants can be anchored by packing their roots in the sand or gravel, and, if necessary, large pebbles can be placed about the bases of the plants until they become firmly rooted, or the lower end of the stem may be weighted by wrapping with a small piece of soft lead just above the roots. Some aquarists insist that a layer of soil should first be placed under the gravel, but with completely aquatic plants this is quite unnecessary, while the soil is often a source of danger to the animal life through the decomposition of its organic ingredients.

If the aquarium is to support its full quota of animal life, the plants must be thickly placed. In fact, there can hardly be too much vegetation so long as the fishes have sufficient room to swim about. The plants tend to mass at the top of the aquarium leaving free space below for the fishes.

To obtain the best results, the aquarium should be planted at least a few days before the animals are introduced. This allows the plants a better opportunity for taking hold of the sand and it also permits them to thoroughly aerate the water in preparation for the animal life.

In order to prevent the possible introduction of parasites into the aquarium along with the plants it is well to sterilize the latter before placing them in the tank. This can be done by immersing the plants for ten or fifteen minutes in a solution of creolin—two teaspoonfuls to the gallon of water. The plants should be well rinsed in water before they are placed in the aquarium. Phenol sodique solution—a tablespoonful to a quart of water—is also highly recommended. The plants should be allowed to remain in this solution for several hours and should, of course, be thoroughly rinsed after removal from the antiseptic bath.

In the selection of plants the beginner, especially if he lives in a large city, will probably have to depend largely upon the dealer. As there are many kinds of plants suitable for the aquarium there is a wide range of choice, according to the tastes of the individual.

The best species for aeration are those that will live entirely submerged and which have (1) narrow, ribbon-like, or (2) finely divided leaves.

In the first class are the tapegrass (*Vallisneria*), arrowhead (*Sagittaria*) and pondweed (*Potamogeton*); and in the second class, fanwort (*Cabomba*), milfoil (*Myriophyllum*), hornwort (*Ceratophyllum*) and waterweed (*Anacharis*).

The fanwort is the most difficult of the plants mentioned to grow properly and is less satisfactory for aeration than many others, yet it seems to be the form most usually sold by the dealers. The others mentioned give little trouble, even to the beginner. If a single species is purchased the beginner will probably find Sagittaria or Anacharis the most satisfactory. Two or three of these plants placed together in the tank give a little diversity and make it more attractive than will a single species. Nearly all of these plants will slip readily and the slips will soon form their own roots if anchored to the bottom by a pebble or a strip of lead. The tapegrass sends out runners, from the joints of which young shoots arise.

The plants must, of course, be provided with a sufficient amount of light or they will not grow, as they are able to manufacture their food only in the presence of sunlight. For reasons stated elsewhere the north window affords the best light for the aquarium. If the plants grow too luxuriantly they can readily be trimmed. Some aquarists prefer to trim off all the parts that come to the surface, thus keeping the plants entirely submerged. There is no doubt that such a method affords the maximum of aeration, since the more the plants are submerged, the less is the opportunity afforded for the escape of oxygen at the surface.

However, many persons prefer the appearance of some plants floating at the surface, and there can be no objection to this so long as there is a sufficient amount submerged. Perhaps the most picturesque, and therefore the most satisfactory, results for the average person are obtained by providing at least two kinds of plants, one like the arrowhead or pondweed with broad leaves which are allowed to float at the surface, and the other with finely divided leaves (milfoil, fanwort, etc.), kept

COMMON BROOK SUCKER.
A native fish that thrives well.

submerged by trimming. The little duckweed (*Lemna*) which floats entirely at the surface with its tiny roots hanging straight down in the water for a short distance, the moss-fern (*Salvinia*), the thread-like bladderwort (*Utricularia*) and the floating *Riccia* are all well adapted to the conditions of the small aquarium and add greatly to its attractiveness.

The plants available for aquarium purposes are entirely too numerous to mention here. There are many native species, some of which can be secured in nearly every pond and stream. They are generally annuals and do not live indefinitely, and the most satisfactory ones are those handled by the dealers, since these are cultivated especially for the purpose. These for the most part have been introduced from the tropics, where they flourish perennially.

Following is a list of those most commonly used:

SUBMERGED PLANTS.

Fanwort (Cabomba caroliniana).
Pink fanwort (Cabomba rosaefolia).
Mermaid weed (Proserpinaca palustris).
Willow moss (Fontinalis antipyretica).
Common starwort (Callitriche verna).
Hornwort (Ceratophyllum demersum).
Canadian waterweed (Elodea canadensis).

Dense Waterweed (Elodea densa).
Narrow-leaved Waterweed (Elodea angustifolia).
Tapegrass (Valisneria spiralis).
Waterviolet or Waterfeather (Hottonia palustris).
Mudplant or Kidney-leaved Heteranthera (Heteranthera reniformis).
Wavy-leaved Pondweed (Potamogeton crispus).
Dense Pondweed (Potamogeton densus).
Swimming Arrowhead (Sagittaria natans).
Narrow-leaved False Loosestrife (Ludwigia linearis).
Water-aloe, Water shears (Stratiotes aloides).
Swimming Arrow wort (Sagittaria natans).
The Creeping Rush (Juncus repens).
Water Milfoil or Thousand-leaf (Myriophyllum heterophyllum).

FREE SWIMMING PLANTS.

Common Bladderwort (Utricularia vulgaris).
Southern Bladderwort (Utricularia americana).
Frogbite (Hydrocharis morsus-ranae).
Small Duckweed (Lemna minor).
Three-leaved Duckweed (Lemna trisulca).
Floating Salvinia (Salvinia natans).
Moss-fern (Salvinia auriculata).
Floating Riccia (Riccia fluitans).
Water Hyacinth (Eichornia crassipes).

STOCKING THE AQUARIUM.

The experienced aquarist will naturally know what he wishes and how to secure it. The beginner should start as simply as possible with only the commoner and hardier fishes and wait until he has proved successful with these before attempting to handle rare or expensive stock. Carps and the ordinary goldfishes known as "commons" are undoubtedly the best for the beginner who is within easy reach of a dealer. The highly bred, fancy varieties of goldfishes are less hardy and the same is generally true of exotic fishes, however attractive they may be.

Almost any of the native fishes may be easily kept and will prove interesting and attractive. Catfishes are perhaps the most hardy, but the various suckers and many of the minnows, as well

YOUNG CATFISH.

The local species of catfishes are hardy and interesting. They are excellent for the beginner.

as young sunfishes, basses, etc., which can be collected with the aid of a small dip net, can be kept readily. The local species should be studied much more commonly than they are at present. Why so many people are satisfied to keep ordinary goldfishes when there is at hand an abundance of attractive native fishes of more lively habits and graceful form, is only to be explained by the fact that the former give so little trouble and can be bought of a dealer instead of collected at a brook. Of course one can easily understand the attitude of the fish fancier who makes a specialty of breeding various strains of goldfishes or of keeping rare exotic forms of bizarre appearance or unusual habits.

Overstocking is the most serious error into which the beginner is likely to fall. In his enthusiasm for the fishes and his love for their attractive colors and movements, he places more specimens in his tank than can be readily provided with oxygen. Often, when they are not all affected in a short time, the result may be that they are gradually enervated until the loss of some of them establishes a proper balance of the animal and vegetable life. Until the management of the aquarium is thoroughly mastered, the rule should be to keep well under the limit of animal life.

COMMON NEWT.

One of the most abundant of the local salamanders and the one best adapted to the balanced aquarium.

It is difficult to lay down any hard and fast rule for this, because the number of fishes that can be kept depends upon their size and kind as well as upon the proportions of the tank and the amount of plant life in good thrifty condition. It may be stated that the beginner will do well to supply only a couple of fishes three or four inches long to an aquarium of five or six gallons of water when the plants are in good condition. A rule often given is—one inch of fish (not counting the tail) to each gallon of water. That is to say, a six-gallon aquarium will ordinarly support six fishes an inch in length, or two fishes three inches long. When he is well acquainted with the habits and appearance of his fishes, the aquarist will be able to know at once when his tanks are overstocked before any losses take place.

Strange fishes should not be introduced into an aquarium with others until they have proved free from disease. They should be kept by themselves for a week at least, and for the purpose of sterilization, may be placed in a bath of permanganate of potash. This substance in stronger solutions is highly poisonous to fishes. The bath in proper concentration, has a light claret color and the fishes should be watched closely while in it. If they show any signs of turning on the side, they should be removed at once to pure water. Snails and other animals may be treated in the same manner for the purpose of disinfection.

There are, of course, many sorts of animals besides fishes that are adapted to aquarium life. The tadpoles, larvae of frogs and toads, are easily collected in any pond, or some of them may be purchased from dealers. In addition to their interesting habits they are useful as scavengers, but unless they are large it will not do to introduce them into the aquarium with carnivorous fishes. In early spring the eggs may be collected and the young reared. The eggs of the frogs are laid in gelatinous masses, those of the toad in long strings.

Of the numerous salamanders, the pale axolotl and the common mud-puppy (*Necturus*) both of which have external gills, are easily kept. The eggs of the mud-puppy can often be obtained in large masses in ponds in early spring, and the larvae may be reared as easily as those of the frog. The most attractive of the native salamanders is the common or spotted water newt (*Diemictylus viridescens*). These beautiful and graceful little animals, though without gills, live well in the aquarium, since they are apparently able to absorb sufficient oxygen through the skin. They swim readily with the limbs folded against the sides,

FOUR STAGES IN THE DEVELOPMENT OF THE FROG.

COMMON SALT-WATER SHRIMP.
They live well in the small aquarium, but not in such great numbers.

and climb with ease among the vegetation. The eggs of the newt are laid singly among water plants.

Young turtles are interesting, but the most of them are better adapted to moist terraria than to the ordinary aquarium as they need to have some way of climbing out of the water. The soft-shelled or fresh-water leather turtle is more aquatic than other species and does not climb out often, but must have loose sand in which it occasionally buries itself.

Young alligators are frequently brought from Florida, but it should be made a punishable offense to do so, for sooner or later they die unless special care is taken to provide them with heat and sunlight. The New York Aquarium is the recipient annually of many of these little fellows, usually in an emaciated condition because they have not fed well, and many of them do not recover, even under the care of an expert aquarist. They

should be considered strictly hothouse pets and handled accordingly.

The temperature of the ordinary living room in winter is too low for young alligations, as they require 80 to 85 degrees for their best development and should not be allowed to drop below 75 degrees. Below this temperature they become sluggish and chilled and refuse to eat.

The pond and river species of crayfishes are well suited to the small aquarium. Those from the mountain streams and cold springs are harder to keep on account of the difficulty of maintaining a sufficiently low temperature during the warm months. They should not be kept with fish smaller than themselves, for they sometimes make too good use of their large pincers. They should be provided with some sort of a retreat in the form of rockwork or stones under which they can hide part of the time on bright days, as they are more or less nocturnal in habit. Some species will climb readily among the water weeds.

There are numerous aquatic insects which can be kept readily and which offer a very attractive field for study. Of those available in the adult stage may be mentioned the hard-shelled water-beetles (*Dytiscus, Hydrophilus*) and the whirligig beetle. The water-bugs, such as the oarsman and the electric-light bug (*Belostoma*) are among the commoner and larger of the true bugs. The larvae of the dragon-flies, caddis-flies and the dobson or helgramite are even more interesting and may be kept until they emerge in the adult winged condition. These forms are chiefly carnivorous and if kept together the smaller may disappear into the rapacious stomachs of the larger. The dragon-fly larvae are even cannibalistic and unless provided with enough food the larger may devour the smaller, even of the same species.

Any of the above forms may be readily collected with the aid of a small dip-net. While their study has been chiefly confined to the entomologist, they will amply repay the labors of the aquarist.

The following list of fishes includes some of the exotic species commonly kept by fanciers. Many of them have no common names. The goldfishes, carps, tenches, ides and orfs are also exotic in origin, but have become domesticated in many places.

Labyrinthine Fishes from India: *Macropodus viridi-auratus* (Paradise fish); *Betta rubra* (Red Fighting-fish); *Betta trifasciata* (Common Fighting-fish); *Trichogaster lalius* (Drawf Gourami); *T. fasciatus* (Striped Gourami), *Osphromenus tri-*

THE SIREN.
This salamander has the legs reduced to mere vestiges. Young specimens are well suited for life in the small aquarium.

chopterus (Spotted Gourami) ; *Ctenops vittatus* (Purring Gourami) ; *Anabas scandens* (Climbing perch).

Viviparous Killi-fishes, Mexico to South America: *Gambusia holbrooki, G. affinis, Girardinus guppyi, Mollienesia* species, *Poecilia* species, *Platypoecilia* species, *Xiphophorus helleri.*

Oviparous Killi-fishes from Central and South America: *Haplochilus* species, *Rivulus* species, *Fundulus* species.

Barbels from India: *Barbus* species, *Danio rerio* (Zebra fish).

Chanchitos from South America: *Heros fasciatus, Geophagus gymnogensis, Hemichromis bimaculatus.*

Characin-fishes from South America: *Tetragonopterus* species.

Loaches from Europe: *Cobitis* species.

ANIMALS THAT WILL LIVE WELL TOGETHER.

In general it may be said that all herbivorous fishes can be kept together safely and carnivorous species should be about the same size when kept in the same tank, though even then it may become necessary to separate some of the more pugnacious specimens which are inclined to "bully" the others.

SOFT-SHELLED TURTLE.
Small specimens are well adapted to the aquarium.

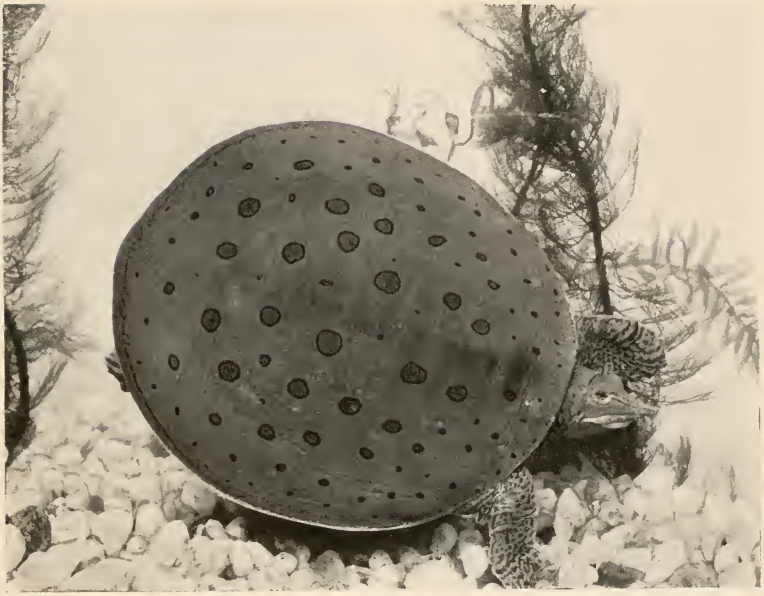
Goldfishes, carps, roach, golden ide and suckers live amicably together, and tadpoles and snails may be kept safely with them.

The fresh-water minnows, such as chubs, shiners, dace, etc., catfishes, killiefishes, the various sunfishes and snails and large tadpoles will live together, though the fishes should be nearly the same size. Sticklebacks, paradise-fish and chanchitos are better kept by themselves, and the black basses and pickerels, unless smaller than the other forms, should also be kept separate. With these fishes it is better to keep only snails, as even large tadpoles may lose their tails by the attacks of the fishes.

The three species of local salt-water killiefishes live well together and tautog, scup, cunner, toadfish, sculpin, etc., if about the same size can be placed in the same tank. Sea anemones, crabs and molluscs too large to be swallowed may be kept with them.

FEEDING.

It is a common but very mistaken notion that an animal should have food at hand at all times to keep it in good condition.



SOFT-SHELLED TURTLE.
Upper side.

It is well known that various forms of domestic animals, as well as the wild species confined in zoological gardens, make the best growth and keep in the most satisfactory condition when supplied only with what food they will clean up at one feeding. This applies with equal force to the inhabitants of the aquarium, but besides *there is a real and grave danger of contaminating the water by supplying more food than will be readily consumed.*

It is a well known fact that some aquarium animals will live for a long time without feeding, especially when kept at lower temperatures, but to maintain them in this condition results eventually in death by starvation and is the worst form of cruelty to which they can be subjected. The effects of starvation may be readily observed on such an animal as the sea-anemone, which, if kept without food, may live for months, but will gradually shrink in size until only a small fraction of its original bulk remains. Higher animals, such as salamanders and fishes, if kept at a low temperature require but little or no food, since many cold-blooded animals naturally spend the colder portion of the year in hibernation, but at the temperature of the living

room all such forms require food more or less regularly since they remain active and so must keep up the necessary supply of energy. If they are deprived of food they become weak and emaciated, lose their vitality and become a ready prey to disease. On the other hand, it may not hurt them or cause any serious discomfort to go without food for a few days occasionally. It is certain, also, that *much of the trouble the tyro finds in balancing the aquarium is due to overfeeding,* especially when unconsumed food is allowed to remain and pollute the water by decaying.

The amount of food a fish requires depends on the temperature. When this is above 60 degrees they may be fed once a day, but if the temperature is lower than 60 degrees, once in two or three days is sufficient. *Any food not consumed within a few minutes should be removed at once.*

In the selection of food one must naturally be governed by the needs of his animals—some species are partly or entirely herbivorous while others are carnivorous. Practically all of our native fishes are carnivorous and thrive best upon a meat diet of some sort, while the goldfishes and carp are largely vegetarian. Prepared fish foods of varying composition may be obtained from the dealer in aquarium supplies, and he may be consulted as to that best adapted to a particular species of fish. The granular foods are in general better than the ordinary wafers which tend to go to pieces too readily and cloud and contaminate the water. In the case of carnivorous fishes, the prepared dry food may be supplemented occasionally by the addition of mealworms, earthworms or fresh beef cut into small pieces according to the size of the fish. Special care should be taken, however, that such animal food is removed if not eaten, as it decays much more readily than vegetable matter and causes greater danger of pollution.

To prevent the dry prepared food from becoming scattered over the surface of the aquarium it is advisable to make use of a floating glass ring which can be secured from a dealer. This not only gives the surface of the aquarium a neater appearance after feeding, but prevents the escape of smaller particles to contaminate the water. Care in the matter of feeding is of the utmost importance in preserving the balance of the aquarium and keeping the animals in good condition. It must be remembered that the usual fault is that of overfeeding and the conditions should be studied carefully.

YOUNG GEOGRAPHIC TURTLES.
Young turtles are very attractive aquarium pets, but should be provided with a float so that they may climb out of the water.

Some turtles will take food only under water, so it is necessary to provide them with a sufficient depth of water to cover them at least during feeding time. This of course does not apply to the tortoise or land turtle. The majority of the water turtles are carnivorous and will take a variety of animal foods, fish, crayfish, frogs and earthworms, living or dead, and fresh beef or hard-boiled eggs. As the different species vary somewhat in their diet this should be studied. Unless they are kept warm they will take no food.

Young alligators usually take readily to almost any sort of meat diet, living or dead, and may be given the same foods as the carnivorous turtles. They will not take food unless kept very warm.

Tadpoles will usually find sufficient food in the debris left after the fishes have taken what they wish, and in the minute plant life of the aquarium, which they assist in keeping under control. Sometimes, however, more tadpoles are introduced into the aquarium than can obtain food in this manner, especially if the aquarium is not sufficiently lighted to encourage the growth of the minute plants, and the tadpoles grow thin from lack of food. There are several ways of meeting this problem: (1) the tank may be placed in better light to encourage plant growth; (2) a larger supply of vegetable food may be introduced so that

WHITE SEA ANEMONE.

the tadpoles may have sufficient after the more active fishes have taken their share. In this case any surplus not consumed should be removed with the pipette after a few hours; (3) the tadpoles may be removed to another receptacle occasionally and fed separately. However, a careful study of the conditions of the aquarium should make this latter method unnecessary.

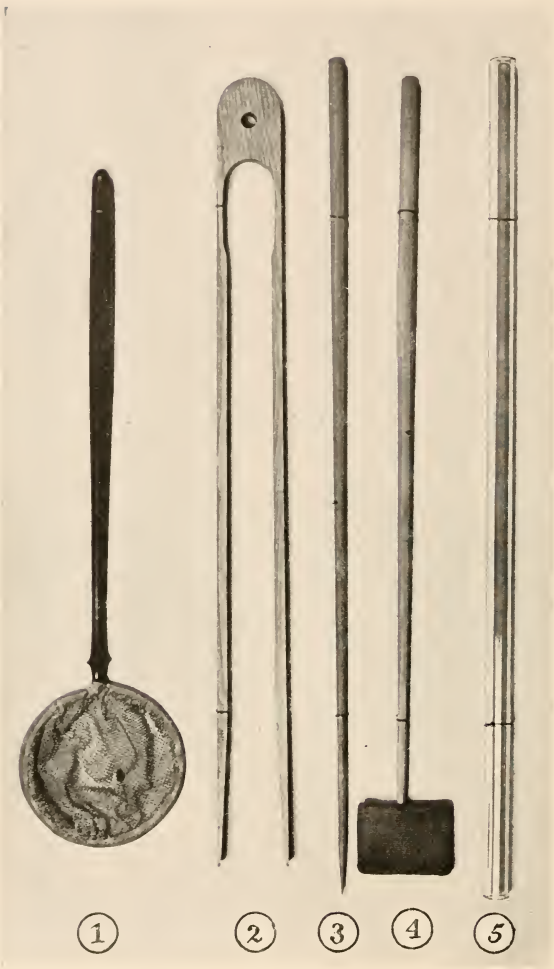
Although tadpoles are vegetarian in their diet, the young frogs and toads after their metamorphosis are strictly carnivorous and are adapted to a flesh diet only. They may be fed on insects, earthworms, mealworms, grubs, or pieces of fresh meat cut to a suitable size. Just at the time of change when the horny jaws of the tadpoles are being shed to allow the development of the teeth, they will take no food. This period of change extends from a few days to several weeks, according to the species and the temperature of the water. These remarks apply equally well to newts and salamanders.

For smaller animals, and especially for attached forms such as the sea-anemone and coral, the use of the feeding-stick is advisable. This is simply a sharp-pointed stick of sufficient length to reach the bottom of the aquarium. The point of the stick is dipped in ground meat or finely minced clam made into a thick paste and carefully introduced into the water until the animal to be fed is reached. With a little care this can be done so as to avoid the loss of much food.

Crayfishes and crabs are naturally scavengers and will eat almost anything. They prefer a meat diet, however, and if deprived of this they are very likely to turn cannibal and eat each other.

CLEANING THE AQUARIUM.

It must be clearly borne in mind that cleanliness is absolutely necessary to the welfare of the inhabitants of the aquarium. In an aquarium which is properly set up contamination can arise only by bacterial decay of organic substances allowed to remain in the water. There are three general sources of such organic matter; first, fecal matter from the animals, relatively unimportant because the deposits are small in amount and regular in occurrence; second, decaying vegetable matter from dead portions of the plants, also relatively unimportant since in the well balanced aquarium there is little tendency for the death of the plant tissues, and third, decay of excess food matter, the usual source of pollution.



IMPLEMENTS OF USE TO THE AQUARIST.
1. Dipnet.
2. Wooden forceps.
3. Feeding stick.
4. Cleaning swab.
5. Glass tube for removing refuse.

The first indication of serious contamination is a slight clouding of the water caused by the presence of countless millions of bacteria. This may go on until the water is of a milky color and the balance of the aquarium is completely upset by the accumulation of sulphur and ammonia compounds set free in the

water by bacterial decomposition. The question, how can the accumulation of dead matter be prevented, is therefore one of the utmost importance. The usual means is to introduce some animal that will act as a scavenger to clean up refuse matter. The forms generally made use of are tadpoles and fresh-water snails. A convenient rule is to supply one snail or large tadpole such as the dealers ordinarily handle, to every two gallons of water, that is to say three snails or tadpoles are sufficient for a six-gallon aquarium. Either of these, under ordinary circumstances, will clean up waste particles of food and decayed vegetation and work over the fecal matter of the fishes, and will also tend to prevent an excessive development of the microscopic plants which form a green scum on the glass. The eggs of the freshwater snails are eaten greedily by fishes and thus serve to add to the natural food supply of the aquarium.

If larger portions of plants begin to deteriorate, it will be found best to cut them off and remove them, since if they are not in good condition they will not serve for aeration, and will become a source of danger.

If care is taken in feeding—and a little study and experience in this matter is the only safe guide—no appreciable amount of food need be left to decay. If, for any reason, the food is not all consumed, or if there is any accumulation of fecal or other matter, it may be readily removed by means of a long pipette, or a rubber tube used as a siphon. For the small aquarium a pipette with an inside diameter of one-quarter to three-eighths of an inch, and fitted with a large rubber bulb is most convenient. In using the tube without the bulb, place the thumb over the upper end of the tube while introducing it, then withdraw the thumb when the tube is immediately over the substance to be removed. The substance will rush up the tube, after which the thumb is replaced while the tube is withdrawn. A special form of glass tube, with an expanded end, recently placed on the market, holds a larger quantity of refuse and must be inverted in order to empty it. This has some distinct advantages over the ordinary straight tube.

For larger aquaria the pipette is rather tedious and the siphon is recommended. In either case the waste should be strained through a cloth net and the water should be returned to the tank rather than add fresh water to replace it. As has been stated elsewhere, the less changing of the water the better, for fear of introducing some new factor to interfere with the adjust-

SEA-LETTUCE (Ulva).
It is the best aerator for the salt-water aquarium. The red-seaweeds add color and variety and should be placed at the bottom of the tank.

ment already established. It will occasionally be necessary to add water to replace that which escapes by evaporation. This should be done a little at a time and care should be taken to have the temperature the same as that of the water in the tank.

For the purpose of removing any deposits on the glass of the aquarium, a swab can be made out of a stick with a bit of cheesecloth wrapped about the end. The cloth may be removed each time it is used, which should not be more often than is necessary to keep the glass reasonably clean, or if it is used again it should be carefully cleaned and sterilized each time in hot water. The swab will serve not only to remove ordinary dirt, but also the green scum of the minute plant life which in strong light will soon cover the glass. These minute plants do no harm—in fact they are as beneficial in yielding oxygen as are the larger ones—and they are a natural part of the balanced life of the aquarium. However one keeps an aquarium to enjoy the view of its miniature water world, and if the green scum interferes with the view it may be removed without great detriment to the adjustment. The scum grows thickest on the side nearest the light and it may be allowed to develop on that side as it will serve to screen the strong light somewhat from the animals.

BALANCED SALT-WATER AQUARIUM.
Showing ulva and red seaweed.

When aquaria are newly arranged, the water may often appear clouded after a few days. If the fishes show signs of discomfort, it is due to the presence of bacteria causing the decomposition of impurities introduced with the sand or from decaying plants. If the fishes appear in good condition the clouding may be due to the presence of great numbers of microscopic animals (infusoria) or plants (diatoms). This condition may even be noticed occasionally in well-balanced aquaria, especially in the spring when the water begins to warm up and particularly if the aquarium is in strong light. It is best in any case to draw off a portion of the water daily and add a fresh supply until the cloudy condition is past. If it is due merely to the presence of infusoria or other minute life, the position of the aquarium should be changed or a screen should be arranged to cut off some of the light. If the fishes show much discomfort they should be removed until the conditions are made right. A careful search should be made for the source of decomposition. If no refuse food nor decaying vegetation is found, the sand or gravel should be removed from the bottom and thoroughly washed and the tank sterilized. The fishes, in the meantime, may be kept in any clean receptacle, and the water changed as often as is necessary. After resetting the aquarium should be allowed to stand for a few days, if possible, before putting the fishes in it.

For removing inanimate objects from the aquarium or for readjusting them, a strong pair of wooden forceps is advisable. The hands should not be put into the water and on no account should the fishes be taken into the hands. If it becomes necessary to remove the fishes, a small net of cheesecloth should be employed and great care should be taken not to injure them by loosening their scales, as any such abrasion offers a foot-hold to the deadly fish fungus (*Saprolegnia*).

MARINE AQUARIA.

As most of what has been said of the fresh water aquarium will apply with equal force to the salt water aquarium, a detailed account will not be necessary. The factors governing life are in general the same in both. The best plants for aerating are the species of green algae known as sea-lettuce (*Ulva*). The most convenient of these to use is the common broad-leaved form. The best means of arranging this is to float each portion at the surface by a small piece of cork placed beneath it. The cork should be just large enough to float the plant, which should be allowed to hang down in the water as far as possible. The species of marine plants are numerous, and the various red, green and brown forms with strap-like or with finely divided fronds may be placed at the bottom to give variety and color, as well as to aid in aerating the water. Very often pebbles with these plants attached may be secured in shallow water.

Unfortunately the salt water aquarium is a practical impossibility for most persons who are unable to make occasional visits to the sea-shore. Artificial sea water can be prepared easily at a trifling expense, if the formula of Gosse is followed: chloride of sodium (common table salt) eighty-one parts, chloride of potassium two parts, chloride of magnesia, ten parts, sulphate of magnesia, (epsom salts) seven parts, total 100 parts. A pound of this mixture is sufficient to make about three gallons of artificial sea water. It should be filtered before placing in the aquarium.

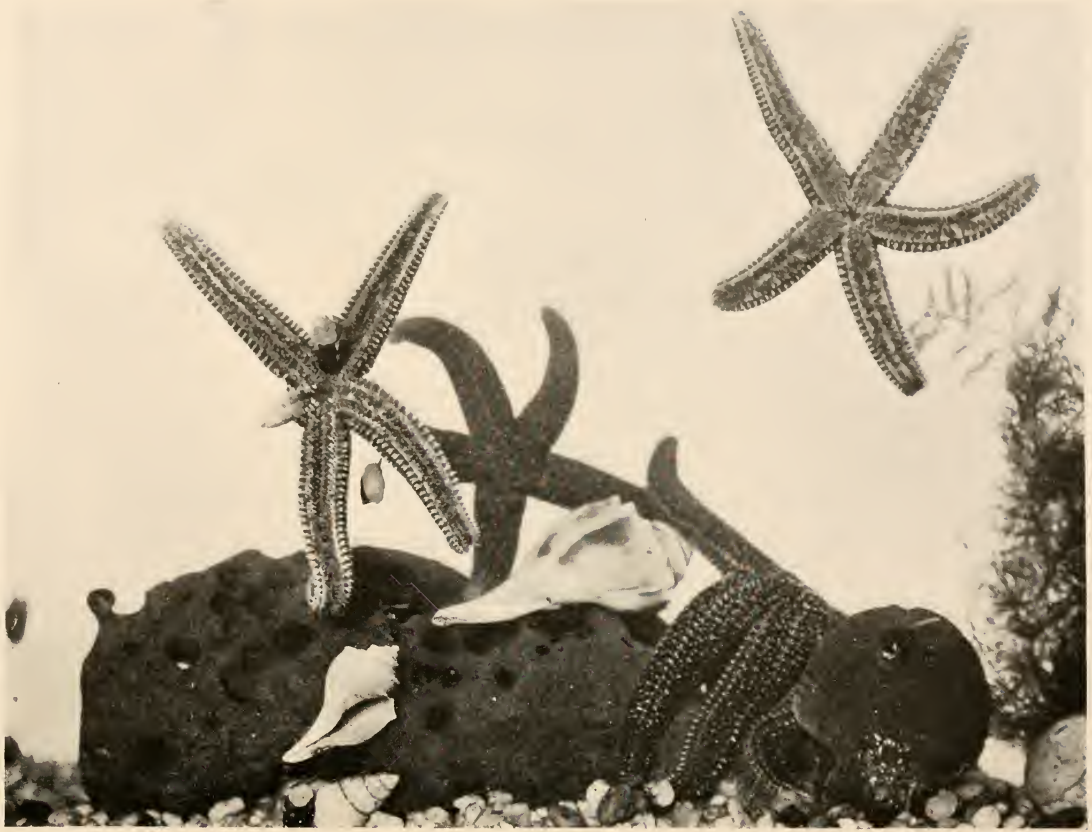
To be sure, natural sea water contains many other salts, but they have been found unnecessary for the plant and animal life of the aquarium and may be omitted. The sea water part of the problem is thus readily solved, but very little marine material is ever handled by dealers in this country and the difficulty of obtaining the necessary animals and plants for the purpose of

YOUNG TAUTOG OR BLACKFISH.
A very hardy and interesting fish for the marine aquarium.

stocking renders the salt-water aquarium impracticable for the person of average means who lives at a distance from the sea.

To one who is within reach of the shore, however, the marine aquarium offers a never-ending and ever-varied field for study and investigation. Animals and plants may be obtained the year round, and many of them live well within the restricted limits of the aquarium. The many species of hydroids and sea-anemones, marine worms, small starfishes, bryozoans, mollusks of many kinds, crabs, shrimps and other crustaceans and sea squirts or ascidians, as well as fishes, are to be obtained. These give a variety to the miniature scene which cannot be paralleled in the fresh water aquarium.

Some of the small salt-water aquaria at the New York Aquarium have been maintained in a balanced condition for several years—one for as long as twelve years. Of course, both animals and plants have been added to the stock occasionally, but the balance has not been interfered with during that time. Fresh water in small quantities must be added to the marine aquarium occasionally to replace that which evaporates. The addition of sea water would, in the course of time, cause the salinity to become too great, since the salts do not evaporate.



STAR-FISH EXPANDED.
The one at the left has grasped a snail preparatory to devouring it.

Special care should be taken, whenever any new animals are added, to observe that they do not die and upset the adjustment of the aquarium by their decomposition. Portions of plants which are deteriorating may be removed and fresh ones added. In fact the whole method of operating is the same as in the fresh-water aquarium, except that greater care is required on account of the greater variety of the animal life and the greater danger of introducing something which will interfere with the adjustment.

Practically all of the marine animals are carnivorous. They may be fed upon pieces of clam, oyster or fish, cut to proper size or finely grated for the smaller animals.

Some sea-snails make good scavengers, but some of them are vegetarians and may attack the plant life too freely, while others are entirely carnivorous and will have nothing to do with decaying matter. However, these are just the points which the aquarist will be interested in determining for himself, and, with the proper attention, will offer no great difficulties. As in the fresh-water aquarium, it is very important not to overfeed and to remove by means of the siphon any excess food material which might, by decaying, interfere with the proper balance of life.

THE TERRARIUM.

Many small animals suitable for the home collection will not live in water and some others which may be kept in the aquarium really prefer moist situations and will do much better in such conditions than if compelled to live in water. For such animals the terrarium is the proper receptacle. Since the animals may vary from the desert lizards, such as the horned-toad, to the moisture-loving land-salamanders, or the frogs, it is evident that the conditions in the terrarium must vary accordingly.

The glass-sided aquarium tank makes a good receptacle for the terrarium. For desert conditions an old leaky one will serve as well as any, and a bottom of dry gravel is all that is necessary. The addition of a few cacti or other desert plants gives variety. These may be planted in shallow dishes, sunk to the level of the bottom. One or two large pebbles may be so placed that the animals can partially conceal themselves beneath them.

For the salamanders and frogs, as well as for land turtles and most insects, more moisture is necessary. A bottom of gravel covered with rich earth should be provided. This should

TERRARIUM IN A ROUND AQUARIUM JAR.
Suitable for small salamanders, frogs and some turtles, land snails, etc.

be kept moist but not sloppy, with frequent watering. Mosses, liverwort and semi-aquatic plants, such as may be obtained in any wet woodland, will grow well and make an attractive environment for the animal life. It is usually advisable to sink a shallow dish to the level of the earth in one corner of the terrarium, as some animals, such as turtles, frogs and salamanders, may find it necessary to enter the water occasionally. Such a terrarium should be in a good light and should be placed according to the suggestions already given for the aquarium. It should be guarded in a similar way from draughts. It is often advisable to cover the moist terrarium with a plate of glass which will prevent evaporation of the water and will keep the enclosed atmosphere at the right point of saturation. In such case the moisture will often condense upon the cover and sides of the receptacle and run back to the bottom. Oxygen for the respiration of the inhabitants is provided, as in the aquarium, by the plant life, and in turn the animals provide carbon dioxide for the plant life. The removal of the cover for occasional feeding or cleaning will sufficiently renew the atmosphere, if necessary, but if properly balanced no such renewal is required. If mold tends

MUDFISH OR BOWFIN.
This is one of the hardiest of fresh-water fishes, but adult specimens are too large for small aquaria.

to form too freely, it is an indication that the soil contains too much organic matter, or that some of the plants are decaying. The cover may be removed and the terrarium allowed to dry out partially to prevent the mold from forming too freely.

The well planted terrarium with a good variety of plant and animal life is exceedingly attractive. Larger ones may be built like a show-case with glass top and sides held in place by wooden or metal frame. The writer has recently seen such a terrarium made with a cement bottom which was fashioned to contain a miniature pool a few inches in depth for gold fishes, frogs and salamanders. The arrangement may be varied indefinitely and very elaborate designs may be worked out in the planting, but in the opinion of the writer the most interesting are those which simulate as nearly as possible the mossy nook or other bit of wild nature.

DISEASES AND PARASITES.

Diseases: Many diseases of fishes are difficult to diagnose correctly. When fishes which have been active and bright colored become languid in their movements, or lose their colors, if they assume abnormal positions, such as swimming head downward, if they rub themselves frequently against the gravel or plant stems, if they keep always at the surface, if swellings or blotches appear, if the scales stand out from the skin, if they refuse to take food, or, if they behave otherwise in an unusual manner, it

may be taken for granted that something is wrong, and a careful study should be made to ascertain the exact nature of the difficulty.

The most frequent cause of trouble for the beginner is lack of oxygen. The symptoms are rapid or labored breathing or the fishes remain at the surface and often take air-bubbles into their mouths. On adding fresh water they should become normal in a little while. Before changing the water in a balanced aquarium it may be better to try aerating by dipping it up and pouring it back in a slender stream from the height of a foot or so. By this means small air bubbles will be carried under, and within a few minutes the oxygen in the water will be renewed. It must be remembered that insufficient oxygen means partial suffocation and therefore continual distress to the fishes until a satisfactory condition of aeration is established.

On dark days, when the plants are not giving off much oxygen, or if the temperature is too high, so that the water does not so readily retain the oxygen, the fishes may remain at the surface. If they insist on doing this in bright weather with the temperature of the water not above 65 or 70 degrees there is something wrong with the balance which should be remedied at once before the fishes are weakened and rendered subject to disease. It may result from decomposition of unconsumed food or of a dead snail, and cleaning should be resorted to at once. If the condition comes on gradually, it is probably caused by lack of plant growth. At any rate, the balance is disturbed and must be restored before graver difficulties follow.

Of organic diseases in fishes we know very little, except that such do exist. The most common troubles affecting aquarium fishes are due to improper feeding. The first result is, of course, intestinal trouble, either diarrhoea or constipation. The latter is more easily diagnosed, as the evidences are a distended or bloated condition of the abdomen, coupled with difficulty in voiding excrement. Over-feeding and improper foods are the main causes. In any case the diet should be cut down—starvation for a few days will not hurt the fishes in the least—and afterwards they should be fed sparingly on prepared fish-food until the symptoms are no longer observed.

Another disease marked by a bloated appearance is that known as dropsy. In this case other parts than the abdomen are affected, and the distension of the skin causes the scales to stand

COMMON ROACH IN A BALANCED AQUARIUM.
A very graceful and attractive species.

out, producing a very rough appearance. Nothing definite is known as to the cause of this disease and if it has made much progress there seems to be no cure for it. In such a case it is better to kill the fish at once and thus put it out of its misery. If the fish is a valuable one and the disease is incipient, it may pay to attempt to cure it by putting the fish on a scanty diet and giving it a tank by itself where it will have plenty of room and the best conditions of temperature, light and oxygen.

Chill is a frequent source of trouble and to avoid this the fishes should be kept from draughts in winter and water should not be added to the tank until it has been warmed to the temperature of that in the aquarium. If they should happen to become chilled, remove the aquarium to a warm place at once and put in some warm water raising the temperature to 80 or 85 degrees, afterward allowing it to fall gradually to the normal. If prompt action is taken no loss should occur. Frequent sudden changes in temperature are very deleterious and should be avoided absolutely.

Other diseases are known to occur among fishes, but very few of them have been studied with any care. Perhaps the best known is the thyroid disease, or goitre, of the salmonoid fishes which has been a subject of much investigation in recent years. This has been proved to result from improper conditions in the

hatching and breeding tanks, to improper feeding, etc., and the disease yields readily enough to proper treatment. So far as known this condition does not attack inhabitants of the small aquarium.

Parasites: These may be plant or animal and are either external or internal in their mode of attack. The plant parasites are either fungus (*Saprolegnia*, etc., or water mold), or bacteria. The fungus is perhaps the most common parasite attacking aquarium fishes. The disease is propagated by means of very minute spores carried in the water. Probably fishes that are in a perfectly healthy condition are not attacked, but if any abrasion occurs on the skin, an opportunity is given for the development of the spores, or if the fish is weak and anaemic, the gills or the tails, especially in the long-tailed goldfishes, may be the seat of attack. The first evidence of the disease on the skin is the presence of a white blotch or blotches, which, on close inspection, is seen to be made up of minute strands (*hyphae*) having something the appearance of absorbent cotton. If not checked at once, numerous spores will be produced on the outer ends of these threads, and be disseminated through the water of the aquarium to the danger of other fishes. On the appearance of this disease in the aquarium it is best to remove all the fish at once and disinfect the aquarium thoroughly. This may be done by treating the tank with a strong solution of salt, while the plants may be placed for a few hours in a solution of phenol sodique (a tablespoonful to a gallon of water). The fish attacked by the disease should be removed at once from those not affected and kept separate until all evidence of the disease has disappeared. For treatment they should be placed in a three per cent. solution of common salt for an hour or so. If they show any signs of distress, such as inability to keep their balance, after they have been in the salt bath a while, they must be removed at once to fresh water. The treatment should be repeated daily until all evidence of the fungus has disappeared. This treatment applies also when the fungus is on the gills. If the disease attacks merely the skin, it may also be treated by local application of a 50 per cent. solution of peroxide of hydrogen, the fish being removed from the water for a few moments while the application is made. A solution of potassium permanganate (dark claret color) may be used in a similar way for local treatment, or the fishes may be placed in a weak solution of the

YOUNG MIRROR CARP.
The carps are very hardy and are excellent fishes for the beginner.

permanganate (light claret color) until signs of distress appear, when they must be replaced at once in fresh water.

When the fungus disease has made much progress it is better to kill the fish at once and be done with it, for there is little hope of saving it or even of giving it a presentable appearance. The threads, or hyphae, of the fungus work their way into the tissues and usually the best that can be accomplished by any treatment is to remove merely the external growth without reaching the pernicious internal portion which continues to develop. If the diseased spot is small and not too near a vital part, it may be carefully scraped and treated with the peroxide or permanganate solution (deep claret color) and thus the internal portions of the parasite may be reached and killed. When the disease attacks the gills there is practically no hope of saving the life of the fish as the growth of the fungus has usually progressed to a critical stage before it becomes noticeable.

Eggs of fish are also frequently attacked by fungus and in this case all eggs diseased must be removed at once.

Bacteria.—These minute organisms attack fishes in various ways. The skin is sometimes affected by what is known as the "slime disease," in which the skin is coated with a whitish mucous-like substance. In the so-called "scurvy" the scales are partially erected, giving a rough appearance. The gills are also attacked by bacteria which cause the filaments to become agglutinated and covered with a thick layer of mucous which prevents

their functioning. This disease is known among fish breeders as "tuberculosis." The "red disease" of the skin of goldfish, ide and other cyprinid fishes is also bacterial in origin. The weaker permanganate solution and a 2% solution of common salt have been used with some success in the treatment of these diseases. What part bacteria play in causing internal diseases of fishes is but little known, although diseases of the liver and other internal organs have been ascribed to this cause.

Animal Parasites.—Apparently these are much more numerous in species than are the plant parasites and they belong to several classes. Among the larger ones may be mentioned the leeches, crustacean parasites or fish-lice and worms (tape-worm, trematode and round-worm). External parasites, if large, ordinarily give but little trouble as they may be readily removed with fine tweezers.

Minute species of trematodes or fluke-worms (*Gyrodactylus*, etc.), are sources of great loss, at times causing the death of whole schools of goldfish. These tiny parasites are almost microscopic, but can readily be seen with an ordinary lens. On young fish they may be found all over the body and even in older specimens they may occur in such numbers upon the skin that they produce serious sores, but adult specimens are more frequently injured by attacks on the gills. Sal ammoniac in one-half per cent. solution, common salt in two per cent. solution, and potassium permanganate in the weaker solution, say one part to 10,000 are all recommended for treatment. However, when the parasites attack the gills in large numbers it is practically impossible to effect a cure, as any treatment fatal to the parasites is likely also to prove fatal to the fish.

Internal parasites, as a rule, cannot be diagnosed, but they seldom cause much trouble among aquarium fishes. To be sure many forms of parasitic worms have been described as inhabiting the intestinal tract or embedded in the flesh. But even if it were possible to diagnose these cases in life, it would probably be impossible to effect any cures.

A number of species of unicellular parasites (Protozoa) attack the skin of various fishes in the aquarium. Usually the presence of the parasites becomes evident to the naked eye as minute whitish flecks or protuberances on the skin. The fish becomes languid in its movements, refuses to take food and breathes rapidly in a labored manner. Two of the better known of these parasites, *Costia* and *Chilodon*, attack the skin exter-

STICKLEBACKS.
These miniature fishes are found both in fresh and salt water. Their nesting habits are especially interesting.

nally and often cause serious losses. The two per cent. solution of common salt and the weaker solution of potassium permanganate are recommended, baths of one-half hour duration being given daily until the disease is eradicated. Another protozoan attacking the skin, which is a far more serious pest, is *Ichthyophthirius,* which burrows into the epidermis producing minute capsules. Fish attacked by this parasite behave much as in the case of those just mentioned. Owing to the fact that the parasites are embedded in the skin, treatment is more difficult. Subjecting the fish daily for an hour or so to a water temperature of 30 to 32 degrees Centigrade (86 to 90 Fahr.) is said to be effiicacious in producing a cure. Also daily treatment with 8 per cent. solution of common salt as long as the fish can stand it is recommended.

Protozoa, belonging to the group known as *Myxosporidia,* are of rather common occurrence and are responsible for some loss. These one-celled parasites penetrate the tissues and in the later stages of development cause tumor-like growths. These may affect the internal organs such as the liver, spleen, kidney or reproductive glands, in which case their presence is not suspected until the fish die. Frequently, however, the cysts are formed under the skin, producing unsightly swellings on the surface

known commonly as fish-pox. Eventually the cysts or swellings break and numerous spore-like cells are liberated. As it is by means of these spores that the disease spreads, the affected fishes should be removed as soon as the swellings make their appearance. There is no specific for this disease, but the cysts may be lanced, and peroxide of hydrogen or the stronger solution of potassium permanganate introduced into the wound with a small pipette. If the cysts are small and not too near a vital part, the fish sometimes recovers without treatment, but, as a rule, the disease is fatal. Both fresh and salt water fishes are attacked by these protozoan parasites, but fortunately the cultivated forms of aquarium fishes are seldom affected. Wild fishes, such as minnows, killifishes, etc., may have the disease in its early stages when taken, and, if later the swellings which cause the disease should make their appearance, the affected fishes should be isolated at once for treatment, or if not valuable it is better to destroy them.

THE CARE OF YOUNG FISHES.

The breeding habits of aquarium fishes vary to such an extent that it is practically impossible to lay down any general rules to cover all cases. Nor is it possible here to more than outline the methods of treatment for a few of the many species.

According to their manner of reproduction, fishes naturally form two classes. Some species, such as the goldfishes, sticklebacks and chanchitos are oviparous and lay eggs which later hatch out into the young. Others, like the swordtailed minnows (*Xiphophorus*) and topminnows (*Gambusia*), are viviparous or live-bearing and bring forth living young. Practically all fishes are cannibalistic in habit at certain stages and do not hesitate to eat even their own young. In the case of the live-bearing fishes, a good method of protecting the young is to place a plate of glass in a slanting position in the aquarium so as to shut off the adults at one side. The glass should fit loosely enough so that the young fishes can find their way into the body of the tank past the edges of the glass, while the adults are unable to do so. After the birth of the young, the adults should be removed to another jar. The swollen appearance of the female is an indication that the preliminary arrangements should be made.

In the case of the nest building oviparous fishes, such as the sticklebacks and chanchitos, the eggs are cared for by the adults

TUBULARIA AND ASTRANGIA, OR WHITE CORAL, EXPANDED.

until the young hatch out, and often for a considerable period after this. The adults may be removed, however, as soon as the young have made their appearance and begin to swim about.

As goldfishes are reared with much more frequency than any other fish, it may be well to go into the matter a little more fully with them. The sexes can be distinguished readily as breeding time approaches by the fact that the belly of the female is greatly distended with eggs, while the male is more slender. The difference in form is much more evident from the top than from the side view. They can be distinguished also by watching their actions, as the male tends to chase the female about the tank, and becomes much more active in this a day or so before the time for egg laying. If there is an abundance of vegetation in the tank, and if the aquarist is not particularly anxious to secure the very best results, he may allow nature to take its course, in which case some of the eggs will be attached to the plants during oviposition, while others will fall to the bottom, probably to be lost. Any fishes not engaged in the processes of egg-laying or fertilization may also occupy themselves in eating some of the eggs. At any rate, after the eggs are laid, all the adults should be removed to another tank, for if they are left with the eggs they may eat a large portion of them and also devour the young fishes after they emerge.

Probably the best method for securing the highest percentage of young is that of placing a cheesecloth net in the aquarium. This should be partially filled with water plants and a breeding female with one or more males placed in it as the time for egg-laying approaches. After the process is complete, the fishes may be replaced in the body of the tank, the plants removed to another jar or breeding pan, and, if any eggs have adhered to the net, as is usually the case, it also may be placed in the breeding pan.

When the young emerge, they will, of course, need to be fed. The natural food of the young goldfish consists of minute crustacea and other tiny water animals and these may be reared in cultures ready for their use. If this is not possible, they may be fed on the yolks of hard-boiled eggs, finely rubbed up, and they will thrive well on this diet. As they get a little older fine portions of prepared fish food may be added. Boiled oatmeal and other cereals strained through a fine sieve or coarse cloth are also recommended. Care must naturally be taken not to overfeed to the extent that the water becomes contaminated.

THE USES OF LENSES.

The observation of the smaller life of the aquarium is rendered easier and much more attractive by the use of lenses. For the study of the very minute forms nothing will suffice, of course, except the compound microscope. For those which are somewhat larger and yet too small to be well observed by the naked eye, the simpler hand lens will be satisfactory. Even a large-sized reading glass, magnifying only two or three diameters, is very useful, and may be arranged to stand permanently before the aquarium jar. A cabinet, which has been in use at the New York Aquarium for some years, is arranged so as to cut out the view of everything except what can be seen through the lens and it is lighted by incandescent lights placed behind the aquarium jars. A reading-glass is easily arranged in a light frame of wood placed in front of an aquarium lighted from a window. By this means the exhibition of aquatic insects and larvae, the smaller crustaceans, hydroids, sea-anemones, sea-mosses, etc., may be made very attractive with little expense.

For the study of very young fish, mosquito larvae, small crustaceans, etc., it is advisable to have lenses of higher magnifying power. Those magnifying six or eight times are perhaps

best for the beginner since the higher powers have a smaller field and are increasingly difficult to manage.

THE STUDY OF AQUARIA.

The aquarium student will naturally be interested in obtaining all the information he can, not only on the care and management of his aquarium, but also with regard to the natural history of his animals and plants. There are several means of accomplishing this end.

In the first place, the aquarium society affords a splendid opportunity for comparing notes with others who are interested, and many of the problems that confront the beginner can be solved immediately in conference with more experienced aquarists. Also much information regarding the habits and life histories of aquarium plants and animals may be obtained in the same manner, and a good opportunity is presented for the exchange of specimens. Aquarium societies exist in New York, Brooklyn, Philadelphia, Chicago, Minneapolis, Boston and Milwaukee, but the number should be greatly increased. In every city there are many people interested in aquaria, and it often happens that a small society will do better work than a larger one, on account of the greater opportunity for personal contact and informal discussion.

Secondly, a vast amount of information can best be obtained through the published works dealing with the subject. The appended list includes only such as are contained in the New York Aquarium library, all of which can be recommended to the amateur aquarist. There are undoubtedly many other useful books on this subject. Most of those issued by American publishers are still to be obtained from the regular booksellers, but a few are out of print and can only be picked up occasionally from the second-hand dealers.

Thirdly, there are numerous foreign and one American journal devoted to the small aquarium and its inhabitants. Subscription to at least one, preferably *The Aquarium,* which is published jointly by the American societies, is strongly recommended as the best means of keeping in touch with advancement in the study of aquaria and aquarium organisms.

PUBLICATIONS OF INTEREST TO THE AQUARIST.

OLDER WORKS.

The Aquarium.— An unveiling of the wonders of the deep sea. With colored plates. By Philip Henry Gosse, A.L.A. Van Voorst, London, 1854.

Popular History of the Aquarium of Marine and Fresh Water Animals and Plants.— With colored plates. By G. B. Sowerby, F.L.S. Reeve, London, 1857.

Ocean Gardens.— The history of the marine aquarium, and the best methods now adopted for its establishment and preservation. With colored plates. By H. Noel Humphreys, Samson Low Son & Co., London, 1857.

The Aquarium Naturalist.— A manual for the seaside, with a chapter on aquaria. Colored plates. By Thos. Rymer Jones, F.R.S. Van Voorst, London, 1858.

The Fresh and Salt Water Aquarium.— With colored plates. By Rev. J. C. Wood, M.A., F.L.S. Routledge & Sons, London, 1868.

The Family Aquarium.— The construction, stocking and maintenance of fresh water and marine aquaria. By H. D. Butler. Dick & Fitzgerald, New York, 1858.

RECENT WORKS.

The Amateur Aquarist.— How to equip and maintain a self-sustaining aquarium. Illustrated. By Mark Samuel. Baker & Taylor Co., New York, 1894.

The Aquarium.— Its inhabitants, structure and management. Illustrated. By J. E. Taylor, Ph.D. New Edition, Grant, Edinburgh, 1901.

The Book of Aquaria.— Being a practical guide to the construction, arrangement and management of fresh water and marine aquaria. Illustrated. By the Rev. Gregory C. Bateman, A.K.C., and Reginald A. R. Bennett, M.A. Part I, Fresh Water Aquaria, Part II, Marine Aquaria. Scribner's, New York, 1902.

The Home Aquarium, and How to Care for It.— A guide to its fishes, and other animals and plants, with many illustrations. By Eugene Smith. Duttons, New York, 1902.

The Fresh Water Aquarium and Its Inhabitants.— A practical guide, describing especially the plants and animals suitable for aquarium purposes, and with chapters on feeding and fish diseases. Illustrated by E. F. Keller and E. R. Sanborn. By O. Eggeling and F. Ehrenberg. Holt & Co., New York, 1908.

Das Susswasser-Aquarium.— A practical guide in the German. Illustrated. By Dr. E. Bade, Fritz Pfennigstorff, Berlin, 1909. Can be obtained through dealers importing German books.

Domesticated Fish.— Care and culture of ornamental domestic and foreign fish. By W. L. Brind, 500 Isham St., New York. The first part of this work has just been issued.

GOLDFISH CULTURE.

The Goldfish and Its Systematic Culture.— A thorough guide for goldfish keeping and goldfish breeding in the house and out of doors. The construction and care of the parlor aquarium and of ponds for breeding. Illustrated. By Hugo Mulertt, New York, 1902.

Goldfish Breeds and Other Aquarium Fishes.— Their correct propagation. A guide to fresh water and marine aquaria, their flora, fauna and management. Illustrated. By H. T. Wolf. Innes & Sons, Philadelphia, 1908.

Japanese Goldfishes, Their Varieties and Cultivation.— A practical guide to the Japanese methods of goldfish culture for amateurs and professionals. Illustrated, with numerous colored plates. By H. M. Smith, U. S. Deputy Commissioner of Fisheries. W. T. Roberts Co., Washington, 1909.

VIVARIA.

The Vivarium.— Being a practical guide to the construction, arrangement and management of vivaria. Illustrated. By Rev. Gregory C. Bateman, A.K.C. Gill, London, 1897.

JOURNALS.

The Aquarium.— This is the only journal published in America devoted entirely to the small aquarium. It is issued each month, jointly, by the aquarium societies of America "in the interests of the study, care and breeding of aquatic life," at one dollar a year. Editor, J. N. Gage, 8 S. Dearborn St., Chicago, Ill.

NATURAL HISTORY

Ponds and Ditches.— A description of the plants, animals and conditions of life in quiet fresh waters. Illustrated. By M. C. Cooke. E. & J. B. Young & Co., New York, 1885.

Ocean Wonders.— A companion for the seaside. With a chapter on marine and fresh water aquaria. Illustrated. By William E. Damon. Appleton's, New York, 1896.

Life in Ponds and Streams.—With a chapter on aquaria. Colored plates. By W. Furneaux, F.R.G. Longmans, Green & Co., New York, 1896.

The Sea Beach at Ebb Tide.— A guide to the study of the sea weeds and the lower animal life between tide marks. Illustrated. By A. F. Arnold. The Century Co., New York, 1901.

The Sea Shore.— Dealing with marine animals and plants and with a chapter on the salt water aquarium. Illustrated. By W. S. Furneaux. Longmans, Green & Co., New York, 1903.

Sea Shore Life.— The invertebrates of the New York Coast (Vol. I New York Aquarium Nature Series). 181 pages and 119 illustrations. By Dr. A. G. Mayer. For sale at the Aquarium and by A. S. Barnes and Company, New York.

Library
N. C. State College